THE SUCCESS OF LIMITED LEARNERS
IN ATTAINING GENERAL SCIENCE CONCEPTS
THROUGH PROGRAMMED INSTRUCTION

by

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ABSTRACT

The purpose of this study was to determine whether or not the use of a programmed instruction booklet, as the basic instructional material, could be considered as more appropriate for limited learners than traditional teaching methods. An attempt was made to measure the success that limited learners have in attaining general science concepts through programmed instruction.

The study collected evidence to show if there was any significant difference between normal learners and limited learners in academic science achievement (as measured by pretest and posttest results), when taught using this methodology. The investigation provided evidence to support increased development and use of programmed materials for modified and regular science classrooms.

To assess the achievement in general science concepts, an author-developed examination was implemented as a pretest and later as a posttest following the experimental treatment. The mean scores in achievement were calculated for distinct groups thus enabling a comparison of gains in achievement. A non-equivalent control group with a fixed effects factorial design was used in the investigation. The fixed effects analysis of covariance, using the pretest as the covariate, permitted the separate analysis of learning ability, methods of instruction and a two-way interaction between these variables.
The analysis of covariance produced significant differences for the two main effects. In terms of learning ability normal learners achieved higher than limited learners and the difference was significant at the 0.05 level. For the methods of instruction, students using programmed instruction scored significantly higher than those students taught with the traditional approach. Since there was a significant difference for programmed instruction and no interaction between learning ability and instruction mode, it follows that programmed instruction was better for both groups of students.

The results of the study are that both limited and normal learners were more successful, in terms of acquisition of science knowledge, with programmed instruction than with traditional teaching in terms of posttest mean achievement scores.
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CHAPTER 1

THE PROBLEM AND ITS BACKGROUND

1.0 STATEMENT OF THE PROBLEM

The purpose of this study was to determine how successful limited learners were in attaining general science concepts through the use of a programmed instructional unit. The study collected evidence to show if there was any significant difference between normal learners and limited learners in academic science achievement (as measured by pretest and posttest results) when taught using this methodology. The investigation provided evidence to support increased development and use of programmed materials for modified and regular science classrooms.

From three years experience in teaching modified science, it was suspected that limited learners can be relatively successful when compared with normal students, all instructed by a programmed unit. Due to a limited learner's weak language arts skills and previous lack of success, it was assumed that they would not attain the same achievement level as the regular students. The research question becomes one of relativity as to how successful can these limited learners be.

The specific questions:

1. Are limited learners as successful, in terms of acquisition of science knowledge as the normal learners?
2. Is programmed instruction as successful, in terms of acquisition of science knowledge as traditional teaching?

3. Is there any correlation between the mode of instruction used (programmed or traditional) and learning ability (normal or limited)?

After summarizing the results of previous related studies, no conclusive evidence was obtained regarding programmed instruction and limited learners. Therefore, in this study the research hypotheses were stated in null form, corresponding to the research questions. Each one of the hypotheses was tested for acquisition of science knowledge. The comparison of two independent variables (learning ability and instruction mode), was carried out looking for what effect they have on achievement and acquisition of science concepts. The dependent variable was measured in terms of mean performance on posttest results.

The three null hypotheses, corresponding to the research questions are:

1. There is no significant difference in mean performance in science achievement between limited and normal learners.

2. There is no significant difference in mean performance in science achievement between programmed instruction and traditional teaching.
3. There is no significant correlation between the mode of instruction used and learning ability.

As this study was more explorative than definitive, the .05 level of statistical significance (\(\alpha\)) was used to test each hypothesis.

1.10 DEFINITION OF TERMS

The following subsections discuss the intended meanings of the important, relevant terms used throughout this investigation.

1.11 TRADITIONAL TEACHING

The terms, conventional or traditional teaching include the following instructional procedures and materials:

- textbook study
- written exercises
- lectures
- discussions
- demonstrations
- experiments
- chalkboard drawings
- film presentations
- overhead projection transparencies

The instructors involved in this investigation employed all of these methods during normal, group-paced, classroom sessions.

1.12 PROGRAMMED INSTRUCTION

In any programmed instruction, the materials are designed
so that the learner is required to make a series of responses to a series of problems, either by writing an answer or performing some physical task. In a Skinnerian-type linear program, the statements are given responses. Immediate confirmation of the answer's correctness is a main feature of this technology. The learner may assess personal performance, then repeat or change responses as necessary without requiring the teacher's assistance.

In the generic sense of the term, Ausubel (1968) described programmed instruction as:

...an individualized form of self-instruction in which emphasis is placed on sequentiality, lucidity and graded difficulty in the presentation of learning tasks, on confirmatory and corrective feedback, and on consolidation and subject-matter readiness. An attempt is made to manipulate as optimally as possible all practice, task and transfer variables that are relevant for the acquisition and retention of content (p. 348).

A programmed instruction is usually found at the center of individualized or personalized programmes. The main characteristics of programmed instruction (Cohen, 1964 p. 7) include:

1. brief presentation of new information or materials
2. a high degree of redundancy and prompting
3. inducement of the correct response
4. checking the response
   a.) if correct . . . serves as a reward
   b.) if incorrect . . . indication of a faulty program

Another definition, given by Schramm (1962), stated that by programmed instruction we mean the kind of learning exper-
ience in which a "program" takes the place of a teacher/tutor for the student. The "program" leads them through a set of specified behaviors designed and sequenced to make it more probable that they will behave in a given desired way in the future.

For the purpose of this study, a modified Skinnerian programmed instruction was developed and used by the investigator. The modification consisted of presenting a choice of answers to the learner in some questions. Pilot study results and suggestions from the current Science eight textbook author, (Mr. J. Petrak) indicated that variety in the program style enhances the learners interest. The programmed instruction was developed outside of the thesis. The investigation explores the success that limited learners experienced using this methodology.

A distinction between individualized instruction and programmed instruction will avoid confusion. Individualized instruction aims to provide a complete instructional program designed explicitly for each individual taking into account personal background experience, interest, and capabilities (Carin and Sund, 1975). Programmed instruction is individualized in the sense that it is one to one instruction where students proceed at independent rates through an existing program.
1.13 LIMITED LEARNERS

In this study, limited learners were defined as those students whose academic achievement was considered to be a significant deviation from the normal. This was indicated by previous grade performance, (low C-, D and E) combined with limited achievement levels (the lowest 18%) on the Canadian Test of Basic Skills (C.T.B.S.).

A diverse list of synonyms for limited learners exists in the literature (see Table 1). These terms are often used interchangeably without clear reference to what criteria were used to determine the label.

Table 1.
Various Student Labels

<table>
<thead>
<tr>
<th>Adjustment</th>
<th>Low educational attainment</th>
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<tr>
<td>Culturally deprived</td>
<td>Marginal</td>
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<tr>
<td>Dull normal</td>
<td>Non-Academic</td>
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<tr>
<td>Dumb</td>
<td>Non-Achiever</td>
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<tr>
<td>Educationally disadvantaged</td>
<td>Reluctant learners</td>
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<tr>
<td>Exceptional</td>
<td>Slow learners</td>
</tr>
<tr>
<td>Intellectually backward</td>
<td>Stupid</td>
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<tr>
<td>Limited learners</td>
<td>Terminal</td>
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<tr>
<td>Limited success</td>
<td>Underachievers</td>
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</table>
Merle B. Karnes (1970), defines slow learners as those children who learn at a less rapid rate than normal but not as slowly as the educable mentally retarded. He states an I.Q. for slow learners to range from 75 to 90. These figures correspond with those given by Oxenhorn (1972), to define what he calls the "true low achiever" (p. 38). The fundamental characteristic of these students is their low mental capacity.

Conversely, Oxenhorn continues to describe underachievers as those who show I.Q. scores well within the "normal" range above 90, as high as 110 and in a significant minority of cases, even well above 110. These pupils have the innate ability but are not academically successful in school.

Utley (1961), reports that slow learners cannot learn as fast as their peers. This does not mean that they cannot learn, but require special considerations of instructional methodologies. Limited learners are neither mentally retarded nor average but are often treated as one or the other. Limited learners cannot be identified by the blank expressions on their faces or their slow movements.

There is a trend to unravel some of the above confusion. Healy (1978), makes a distinction between the underachiever, slow learners and disadvantaged students. Each of these labels is then qualified by a substantial list of characteristics.
In summary, limited learners were defined as under-achievers regardless of mental capacity, classroom effort or socioeconomic background. The students in the investigation that are classified as limited learners were identified by four criteria (section 3.3).

1.14 NORMAL LEARNERS

For the purpose of this study, normal or regular learners are those students who have not been screened out of the student population for special treatment. These students rarely achieve failing letter grades and are in the top 82% of the class as indicated by the C.T.B.S. results.

1.15 REGULAR CLASSROOM

The words; regular, normal, traditional, or conventional, when applied to a classroom describe the most common situation for student instruction in British Columbia (B.C.). Students are selected by their age and assembled together for the purpose of group-paced instruction.

1.2 POPULATION OF LIMITED LEARNERS

There are significant numbers of students in secondary schools who have had limited learning success. Estimates of the extent of low attainment among pupils vary with the criteria used to define it. Many writers, while not using the term limited learners conclude that some form of special
educational provision is necessary for at least 15 to 20 percent of a school population (Ferguson 1961, Gulliford 1975, Jenkins 1973, Oxenhorn 1972, Page 1968).

In New York City, the grade 8 science curriculum guide indicates that 20% of all students have achieved limited understanding when compared with each other. This large figure is found in many innercity schools as well as substantial numbers in suburban schools.

Although, there has been no attempt to measure the number of limited learners in B.C., it seems reasonable to suspect that there exists a similar population. Therefore, with a current secondary school population of 198,025 (1981), there must be approximately 29,700 to 39,600 (15 to 20%) limited learners.

1.3 BASIC PREMISE

Science educators are committed to provide secondary school instruction at all levels of student abilities. This position is based upon the belief that science instruction is an essential part of the education of any citizen. The value of science education for all students is reflected in a statement by Fischer (1960):
Because we are a democracy, whose citizens are the ultimate policy makers, large numbers of us must be educated to understand, to support and when necessary, to judge the work of the experts. The public school must educate both the producers and the consumers of scientific services (p.23).

Education in a democratic, enlightened society is grounded on the assumption that we expose all our children, within their own capabilities, to all the primary disciplines of knowledge. Oxenhorn (1972), extends this assumption to a far-reaching educational goal: Scientific Literacy. This term implies the possession of a basic core of learning in the field of science including knowledge, attitudes, skills, and secondly, an ability to increase this possession and become more literate in the sciences. Oxenhorn, concludes that Scientific Literacy is not only for the intellectually elite but for the underachiever as well, in that they too will participate in the democratic process.

In her work with young children (k-3) McIntyre (1973), asserts that if we accept the premise that all children have unique and special needs, by meeting those needs positive results can be attained in our relationship with all children; no progress is made without trying. This trying can be linked to working through the phases of a science experiment. One goal of science education is to meet the needs of students at all levels of ability. Ideally, this goal could be achieved through some form of individualized instruction, that would
Personalize the learning process of each student.

The sum of the viewpoints above can be concluded with a quote from John W. Gardner, (in Oxenhorn, 1972):

The traditional democratic invitation to each individual to achieve the best that is in him requires that we provide each youngster with the particular kind of education which will benefit him. This is the only sense in which equality of opportunity can mean anything. The good society is not one that ignores individual differences but one that deals with them wisely and humanely (p.2).

1.40 PRESENT CONDITIONS

It was perceived that in many traditional classrooms, the student is expected to fit into a predetermined mold. Failure to reach a standard class level often results in remedial work that some students may view as punishment. Despite most teachers' convictions that the pupil is an individual, learns at his own rate, has a unique style or mode of learning, and has different topics of interest and motivation, the majority of science teachers continue with the traditional "class" approach to education. The instruction given is aimed at mythical "average student" who is rarely present (Cardarelli, 1972).

She expresses strong opposition to the traditional approach, claiming that conventional teaching, "does a good job of preparing students for a totalitarian state" (p.28).
Her sentiments become clear as she envisions all students studying the same page at the same time, later fumbling through homework, each student being spoon-fed the knowledge a teacher wishes them to know, and each student totally guided by teacher decision making. The traditional approach to teaching, she contends, actually inhabits the very initiative, creativity, independence and ability to get along with others, that is greatly needed in today's society.

In group-paced instruction, the teacher is frequently aiming for the average or conforming student. Kapfer and Swenson (1968), discussed the impossibility of providing for individual differences with a lesson plan geared for an average student using a single methodology and a common medium. They also acknowledged that even though students learn in different ways and at very different rates, most published curricular materials are designed for group-paced instruction.

In a traditional school setting, student numbers and lack of instructional material often prevents teachers from reaching their ultimate goal. (i.e. to meet the individual needs of each student). Students who are unable to respond positively to grouping or other traditional classroom techniques often fall far behind in the primary grades and suffer from severe basic skill deficiency by the time they have finished elementary school. Walther (1975), reports
that this lack of success engenders a loss of self confidence as such students eventually experience great difficulty coping with learning situations in general and with peer group pressure in particular.

"The most striking evidence of the failure to adjust instruction for individual differences is provided by the low levels of reading ability found and the assignment of inappropriate study materials". Flanagan (1971, p. 173), made the previous comment after noting that 34 percent of grade twelve students have great difficulty in comprehending assignments.

If educators accept the premise that all children should be exposed or challenged to the extent of their abilities, then this objective is not being fulfilled. Science education has traditionally catered to the academic elite, neglecting the slower learners that are always present. Hurd (1969), agreed that minimal progress had been made when the majority of the new nationwide science courses were developed for college preparatory students, especially the classes in chemistry and physics and to a lesser extent, the biology courses.

Since we are living in a scientific age, every possible effort should be made to supply programs or materials at a level that is commensurate with each
student's abilities. As science involves studying life, all pupils regardless of mental capacity, experience natural phenomena. All children have innate curiosities about: life, the Universe, electricity, light, matter, heat, sounds, the Earth and weather. In efforts to adequately challenge average and superior students, Witty (1961), predicted the ever present threat that educators may overlook the limited learners.

1.41 B.C. SCIENCE ASSESSMENT

In the Summary Report to the Ministry of Education (British Columbia Science Assessment, 1978), junior secondary science teachers thought that the provision of a wider selection of printed materials and a complete revision of the junior science program would improve the quality of science instruction. The teachers reported that there appears to be insufficient time to cover the prescribed course and that there is little provision in science for individual differences in student ability.

The 1978 Science Assessment listed the first major goal of science education as Understanding Concepts, followed by Skills in the Process of Science, Application, Safety, Scientific Literacy and Favorable Attitudes to Science and Scientist. General science assessment at the grade eight level was encouraging with student
performance rated as satisfactory or better on 70% of the survey questions. The interpretation panel rated grade four and twelve at 84% and 30% respectively.

In the conclusions and recommendations section of the report, the learning assessment team suggests (p. 44):

1. That the Ministry of Education establish immediately a curriculum revision committee to carry out a major revision of the junior secondary science program.

2. That the Ministry of Education, as a priority item, increase the selection of texts and supplementary reading materials available to teachers of the present junior secondary science curriculum as long as it is in force.

3. That teachers widen their repertoire of methods of teaching science at the junior secondary level, and allocate some of the time now spent on routine marking of laboratory reports to planning different approaches.

They further recommended that a new junior science curriculum was called for, and in the interim, the provision of a wider range of printed materials for junior secondary science. Any new curriculum should be designed to appeal to girls as well as boys, and should be adaptable to the wide ranges both of ability and interest in science at the junior secondary level.
Teacher reports in the Assessment indicated that there was little provision in B.C. science classes for individual differences of student ability and 29% of junior secondary teachers reported no provision at all. The most common provisions at the junior secondary level were learning assistance classes (40%) and ability grouping by classes (38%). In larger schools it is possible to identify and group modified science students. Throughout the province in smaller communities, grouping is not possible due to budget restrictions. Talented instructors can rearrange their own classes into groups, accommodating the slower learners, then attempt to teach each group. This method imparts extra work onto the teacher and only the most capable staff members could continue this arrangement over a longer period of time.

Current junior science programs in B.C. appear to be designed for the successful students, leading them into senior science and college courses. Most non-academic pupils are required to take science courses at least until grade 10, when their science careers may terminate and the Ministerial terms of science education have been met. Underachievers can now either drop-out legally, follow an industrial-technical program or search for a vocational trade.
1.5 A RATIONALE FOR PROGRAMMED INSTRUCTION

An educator cannot justify spending extra time on the slower learners at the expense of normal and advanced students' needs. However, it can be argued that success in a modified science program is more defensible than failure in an unattainable program (Oxenhorn, 1972). A very successful technique for helping limited learners is to employ an individualized program. Ausubel (1968), states that programmed instruction is "potentially the most effective method for transmitting the established content of most subject-matter fields" (p. 348).

A principal theme with program design that is repeatedly stressed in all the literature for dealing with slower learners, is involvement. The students that have had limited success learn best when they come into direct contact with the subject matter and assume some role in organizing the learning approach and sequence (Abraham, 1961).

In a survey conducted by Healy (1978), 74% of teachers reported that the texts and lab manuals in use were only somewhat suitable to unsuitable for teaching science to limited learners. The provincially prescribed textbooks are described as being inadequate for underachievers mainly because of the students' inability in language arts skills.
The slower pupils are unable to comprehend major concepts unless the instructor augments the lessons with special materials. More appropriate textbooks, worksheets, and modified materials are available to those teachers who search resource centres, locate and obtain these items to use in the classroom; this is a very time consuming process.

Healy (1978), reports that 70% of teachers do not provide a special science course for limited learners. Of those that do, 60% reported that they never used programmed learning while 28% used this approach at least once or twice a term. The 1978 B.C. Science Assessment reported that only 22% of teachers noted the prescribed readers as satisfactory, yet 57% of teachers indicated that they assign readings from the texts.

The Science Assessment indicated that there is need for the development of modified science materials that can be readily placed in the teacher's hands. The items must be affordable, easy to implement, guarantee reasonable satisfaction of educational objectives and compliment the existing curriculum. It is not necessary to discard the previous syllabus but rather to construct adjustments in the methodology or process areas which lead to similar conceptual development. Young (1967), proposed that an expedient method for individualizing science courses is by
designing programmed instructional units.

A programmed instruction on the topic, "Light" was developed to augment the learning materials available to non-achievers in B.C. science courses. The programmed instruction was designed to meet the needs of most limited learners at the grade eight level. The program developed follows the core curricular materials and crystallizes the main concepts presented. As homogeneous groupings of underachievers are not feasible in smaller schools, a personalized programmed instruction could be issued or arranged for those individuals selected as being limited learners.

1.6 THE LEARNER AS AN INDIVIDUAL

The major problem of instructing today's students is not the poor quality of materials or inappropriateness of techniques but rather the failure of educational systems to deal with differing student abilities. A learner is an individual and must be taught accordingly (Baker and Goldberg, 1970).

As previously mentioned, some educators believe that in an ideal society, individualized instruction could maximize the learning process of most students. However, with the present facilities and materials available, plus the curricular organization and administrative
constrictions, Burns (1971) relates the difficulty for achieving individualization in a traditional setting.

Burns' statement that individualized instruction is educationally desirable comes from the nature of mankind. Since no two living organisms (pupils) are alike, a register of variables concerning students was constructed examining the logistics of individualization. Burns (p. 55), lists that no two learners:

1. achieve at the same rate
2. achieve using the same study technique
3. solve problems in exactly the same way
4. possess the same repertoire of behaviours
5. possess the same pattern of interests
6. are motivated to achieve to the same degree
7. are motivated to achieve the same goals
8. are ready to learn at the same time
9. have the same capacity to learn

If these nine assumptions are combined with different city, home, and school environments, one must admit that learning is a unique process. This indicates the difficulty of trying to find one textbook or methodology to adequately serve all students in a classroom.

1.7 A SUMMARY OF PERSONALIZED EDUCATION

Personalizing a curriculum requires that provisions
be made for each person's strengths, weaknesses and current knowledge level in the content area being restructured (Carin and Sund, 1975). In individualized instruction, one tries to provide learning opportunities that are in agreement with a student's needs, interests, and aptitudes. Sheehan and Hambleton (1977), stated that at present we lack sufficient theoretical guidelines and empirical results to know just how individualization can be done, results reported in the next chapter demonstrate many areas of success.

Most definitions of personalized instruction specify a concept of instruction or program of study tailored to each student's needs based on their capabilities and characteristics of learning (Burns, 1971). Others imply that it is nothing more than applying logic to the learning act. Then, by carefully planning and organizing, provide an efficient method for learners to have the opportunity to acquire behaviors in their own way at their own rate. Kapfer and Swenson (1968), note the difficulty in trying to describe the term, personalized instruction. It contains high level abstractions which sound good and contain current jargon but do not really offer any specific course of action.

However, when individualizing a program, Bolvin (1968) suggests the following goals. Each student should (p. 239):
1. make continuous progress towards mastery of the instructional content
2. continue this mastery at their own rate
3. engage in the learning process through active involvement
4. view the learning process as primarily self-directed
5. be able to evaluate the quality, extent and rapidity of their progress towards mastery of successive areas in the learning continuum.

Bolvin concludes that it is only through the use of self-instruction materials that personalization will be manageable within the context of present school situations.

1.8: COMPENDIUM

A synopsis of chapter one suggests that the investigation of programmed instruction for limited learners could provide information for teaching limited learners. A group of students having difficulty in school has been identified and an instructional methodology outlined.

The research question concentrated on whether or not the limited learners are more successful with programmed instruction than with traditional teaching. In chapter two a literature survey provides a background of information on limited learners and programmed instruction. An attempt was made to find interacting articles that correspond with both of these subjects.
CHAPTER TWO

LITERATURE REVIEW

2.0 INTRODUCTION

The review of the literature focused on two regions, a profile of the limited learner and research results of programmed instruction in science education. Most researchers investigated one specific aspect of programmed instruction and provide insight for designing future programs. The meager selection of articles involving both the limited learners and programmed instruction does not provide clear answers to the research question. This section begins with an overview of the limited learner, revealing personal qualities that should be considered when developing programmed units for limited learners.
2.1 CAUSES FOR UNDERACHIEVEMENT

"Underachievers are not born, they are made", claims Weider (1973, p. 19). This statement is supported by the work of eight theorists who have associated an emotional sequence with low achievement. The isolation of causes for underachievement is inherently difficult as the complexity of dealing with backgrounds, individual differences and a diversity of needs is enormous.

Many researchers in their effort to generalize the causes have found similar explanations. Jenkins (1973), classifies these causes under five general headings which can be summarized as:

1. Intellectual Factors - Limited intellectual development due to genetics, injury or disease
2. Home Background - home failed to provide adequate opportunities for language development
3. Personality Factor - deviations from normal emotional and social development
4. Physical Factors - prolonged illness, and undernourishment impair learning efficiency
5. School Factors - material facilities, teaching staff characteristics and classroom procedures

Oxenhorn (1972), approaches the factors related to underachievement by listing blockages in a student's
potential to perform. When these blocks; social, economic, racial, physical, emotional or combinations of all these are removed or modified, the achievement level improves.

A further discussion specifies the following causes (p. 37):

1. Previous Underachievement — former lack of success widens the gap with their peers

2. Reading Retardation — either as a cause or effect of low attainment is debatable

3. Low Personal Motivation — elusive factors due to fear, frustration, family or emotional problems

4. Societal Problems — poverty, racial segregation, slum, etc.

5. School Factors — irrelevant curricula, poor methodology, inappropriate school materials, mislabeling

With the exception of the physical factors leading to low attainment, one must conclude that underachievers develop with respect to the detailed information outlined in the literature. One further investigation to compliment this list of causes was undertaken by Bingham (1970). He claims that underachieving youth are a product of inadequate attention along three main lines of activities which have been shown to help a child's intelligence grow (p. 528).

1. Infancy Stimulation — parents unable to provide physical needs nor a stimulating environment
2. Language Activities - minimal early conversation
3. Reading Preparation - hours of reading to, naming items in the environment

To conclude the causes for underachievement, Bruner (1960) predicted that improvements in science teaching may accentuate the gaps already observable between talented, average and slow students in the subject. A quotation from Tanzer (1960), exemplifies this prediction and notes a concern.

A major problem arising from the current reappraisal of science education is the danger that, in our eagerness to raise standards for the average and above average student, we may lose sight of a large segment of our pupil population. Our slow learners are always with us (p. 181).

2.2 PRESENT QUALITIES PERCEIVED

After examining the suggested causes for underachievement, it is necessary to itemize certain qualities that allow an underachiever to be identified in the average classroom. Teachers should be alert for characteristics exhibited by pupils that are summarized by the author in Table 2 and as a generalized, comprehensive summary, not all learners possess these qualities. They can be considered in diagnosing potential candidates and subsequently planning instructional programs for these students.
| TABLE 2 |
| QUALITIES PERCEIVED |

<table>
<thead>
<tr>
<th>KARNES</th>
<th>JENKINS</th>
<th>BINGHAM</th>
<th>OXENHORN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Physical defects</td>
<td>1.* Poor powers of reading and writing</td>
<td>1. Social product</td>
<td>1. Poor reasoning ability</td>
</tr>
<tr>
<td>2. $ Low academic progress</td>
<td>2.* Vocabulary problems</td>
<td>2.# Experience</td>
<td>2.# Poor retention</td>
</tr>
<tr>
<td>3. Poor reasoning ability</td>
<td>3.# Poor retentive memories</td>
<td>3.$ Inferior conceptual development</td>
<td>3.* Communication skills weak</td>
</tr>
<tr>
<td>4. Short attention span</td>
<td>4.**Limited powers of communication</td>
<td>4.* Communication</td>
<td>4. Low curiosity</td>
</tr>
<tr>
<td>5.# Poor retention</td>
<td>5. Disorganization</td>
<td>5. Culture of poverty</td>
<td>5.$ Poor in abstractions</td>
</tr>
<tr>
<td>7.** Poor work habits and motivation</td>
<td>7.$ Reassurance</td>
<td>7. Preferential treatment</td>
<td>7. Concept formation</td>
</tr>
</tbody>
</table>

**COMMON QUALITIES**

- Language and Communication *
- Motivation **
- Retention #
- Previous Success $
The table coordinates the common qualities perceived in limited learners by: Bingham (1970), Jenkins (1973), Karnes (1970) and Oxenhorn (1972). (NOTE: the coded markings indicate similar characteristics as listed by simultaneous authors).

It is not surprising to note the similarity between all the previously recorded causes for underachievement and the qualities perceived in the classroom. To look at these characteristics from a slightly different perspective, Weider (1973), describes what the teacher observes:

In the underachiever there appears to be no motivation, but only an apparent lethargy; eyes which gaze into deep wells of emptiness, an attitude of estrangement or a state of rebelliousness which evades productivity. Disengagement rather than involvement (p. 19).

This interesting report states patterns which describe how the underachiever has formed. Weider provides a psychodynamic analysis of the underachiever which can be summarized as follows:

1. Self Concept - become overly introspective
2. Personal Inadequancies - feels unfulfilled, trapped, pessimistic, discouraged and confused
3. Adult Perception - more realistic, notes adult preaching at variance with actions
4. Needs
- desires immediate gratification but has an unconscious need to fail, seeking parental rejection

Weider concludes his article describing a syndrome of underachievement. The parents often do not know the potential and capacities of their progeny. The student is usually rebelling against his parents to find himself as an independent person. The successful rebellion then takes the form of passive resistance rather than active aggression. The youngster wants to get, "back at the parents through failure" (p. 21).
2.30 GENERAL TEACHING STRATEGIES AND SUGGESTIONS

To cope with the complexity and multiplicity of problems that the limited learner brings into the classroom, special techniques and awareness should be employed by the teacher. Many authors have made suggestions to clarify a successful approach that increases the rate of progress. To alleviate the persistent problems facing the underachiever, lists of strategies have been compiled from Aronstein (1969), Bingham (1968), Holzberg (1976), Karnes (1970), Lombardi and Balch (1976) and Weider (1973).

Since the literature is expansive on this topic, five categories were used to summarize it as follows:

2.31 GENERAL ACTIVITIES

- use a multisensory approach, stress quality not quantity
- introduce concepts from previously acquired knowledge
- teaching should proceed from the known to the unknown with emphasis on the child's daily living activities
- experiments chosen and organized so that immediate application is apparent and relevant
- select activities for immediate success in the minimal amount of time
- give immediate feedback, encouragement and progress reports
- reinforce successful performance with praise
- important learning must be systematically taught, following sequential, organized patterns of instruction
- experiences should require the manipulation of concrete materials to improve visual-motor co-ordination
- select learning experiences which promote active student involvement, encourage their hypotheses
- the key is adaption to the environment, not intimidation by it
- science experiences must be developed from the current, common interests of the learners and result in an understanding of the basic principles
- avoid teaching material on a highly abstract level, use concrete experiences
- create interest through a humanistic approach by using different media sources
- develop a home-science curriculum, coordinate learning at home with learning at school

2.32 COMMUNICATION

- make all instructions short, specific and clear
- topics should furnish a basis for improving all language arts skills, especially reading and oral expression
- increase vocabulary, greater facility of word use allows more effective thinking
- practise language, read student activity sheets together as a class
- discuss outcomes to ensure precise concept formation
- develop new language by using particular objects and events
- have supplementary reading materials available with similar conceptual schemes at appropriate reading levels
- the emphasis of our educational system is on reading, if you cannot read, learning becomes formidable

2.33 TEXTBOOKS

- should be at or below the student's reading level
- minimized emphasis on reading ability through use of diagrams and illustrations
- contain a decreased vocabulary load, technical jargon used only when it relates directly to the present experience
- should provide written accounts of phenomena students have personally observed
- avoid use of irrelevant formulas, symbols and math
- materials of high interest and low vocabulary may be taperecorded to ease comprehension

2.34 TESTS

- should be replicas of activities performed in class
- evaluate general concepts in the same setting
- situation centered involving all skills taught
- should not be a threatening authoritative demand but a natural culmination of work
- employ a timing device so that the learner does not get bogged down on one question
- a simple format will avoid confusion or deception
- write out model answers before the test
- ideally, those with reading problems may be compensated through an oral exam
- should be used primarily to promote learning

2.35 ATTITUIONAL OBJECTIVES

- give an opportunity for students to feel important, become constructive helpers, not destructive delinquents
- encourage creative abilities, questions, self expression
- focus on the positive with an emotional climate conducive to learning
- the teacher accepts every response as a contribution to the development of a concept
- student learns how to resolve frustration through a constructive means
- underachievement is self-defeating and that there are hidden causes for this failure
- overcome fears of school by working with consequent feelings of accomplishment
- develop a mature attitude in route to being a responsible adult
- supply all basic emotional needs
- an awareness of the complex interaction between science, technology and society
- develop the ability to recognize a problem and the confidence to select appropriate skills to solve it
- an unthreatening classroom atmosphere, structured to where the students know what is expected of them

2.4 PROGRAM DESIGNS FOR MODIFIED SCIENCE

To avoid a "watered down" curriculum, Oxenhorn (1972) reveals that a careful analysis of any syllabus shows that it can be adjusted according to the pupil's needs. If instructors think more in terms of content-adjusted and process-adjusted curricula, keeping realistic goals, they retain all the important concepts and arrive at a more meaningful, practicable and strengthened program. Oxenhorn also argues that success through a modified program is more defensible than failure in an unattainable program.

Most authors, including Lombardi and Balch (1976), report that since limited learners are not oriented towards abstract concepts, suitable programs must have a practical application. This does not mean the elimination of theory, concepts or processes of science but that programs should provide the scientific literacy to help pupils function in our society. Modified science programs should be
structured to permit easier comprehension and better retention.

The nature of modification for science instruction designed for limited learners has been mentioned by several educators. Abraham (1961), notes that concreteness is of utmost importance; materials that can be handled and manipulated should be used to make science more meaningful.

Johnson (1963) and Anderson (1966), recommend a laboratory approach as both believe that science for limited learners should be taught as inquiry. This can be extended to an accumulation of discoveries as reported by Younie (1967). Some successful programs for limited learners are described in the literature by Bingham (1968, 1970, 1973 and 1974), Milson (1973), Quayle (1970) and Wheeler (1973). In B.C., the current modified science programs include the Pathways in Science Series by Oxenhorn (1968), Concepts and Challenges in Science by Winkler et al (1974) and Invitations to Investigate Science by Wong (1976).

2.50 PRINCIPLES OF PROGRAMMED INSTRUCTION

Programmed instruction has been called one of the most exciting advances in learning techniques during recent years (Anderson, 1972). Formerly recognized as a simple self-instruction method of shaping verbal behavior, it
has become a process, an integrated instructional system of formulating objectives, and a diagnostic analysis of teaching techniques (Callender, 1969).

The work of Skinner (1961), on the analysis of behavior based on experimental studies with animals, led to the conclusion that by the process of reinforcement the likelihood that a particular activity of an organism will be repeated is increased. Nothing is new in this principle except in understanding how conditions of reinforcement work best.

Programmed instruction rests firmly on a behavioral-science base for its effectiveness. Glaser (1965), has outlined what this base should be for any instructional design. He cites diagnosing of pre-instructional behavior as critical and gives preinstructional variables which can determine course achievement. A list of some conditions that influence the learning process such as; sequencing, stimulus and response factors, self-monitoring, interference, practice, and response contingencies is also provided.

A programmer's job is to analyze the tasks to be performed, construct the sequence and then decide the mode of presentation. Whereas the onus of learning is on the student, the onus of ensuring that the program teaches is on the programmer (Callender, 1969). To achieve this,
the writer must ideally carry out a behavioral analysis of skills to be learned before designing the instructional sequence.

Limited learners need a gentle release from the teacher dominated classroom scene to a more open, exploratory atmosphere, featuring the student-centered approach (Nasca, 1965 and Walther, 1975). In personalizing instruction, the teacher's role becomes that of a manager of learning for individual students. The teacher monitors each student's progress, diagnoses learning problems, prescribes alternative learning materials, and activities to help solve problems and evaluates each student's progress in achieving stated behavioral objectives.

2.51 Behavioral Analysis

The tasks to be learned should be defined and broken down into separate components, (a hierarchy of sub-objectives) so that program objectives can be formulated. As prescribed by Gagne (1970), a hierarchical knowledge structure can be written from these objectives by logical reduction. The instructional sequence should arise from an educational need rather than a programmer's independent decision. The behavioral psychologists, from whom programmed learning originated, have not developed theories but rather techniques (Callender, 1969). They claim that
since little is known of the human mind's workings it is more useful to concentrate on teaching techniques which are seen to produce results.

Komoski (1963), states that educational psychologists believe the best learning environment is one in which five factors are operative (p. 292):

1. The learner is active
2. The learner gets frequent aid and performance feedback.
3. Learning proceeds gradually from the less complex toward the more complex in an orderly fashion.
4. The learner is allowed to develop his own best pace of learning.
5. The teacher's strategies are constantly reappraised on the basis of an objective analysis of the learner's activity.

It is the responsibility of the program designer to determine whether materials and procedures enable the student to reach the desired performance level in a specific subject. In these terms, learning can be defined as a change of behavior that is both observable and measurable (Callender, 1969). When listing objectives, expressions such as: to know, understand or appreciate are vague and meaningless descriptions. They are not behavioral terms as they cannot be measured or observed without asking the learners to demonstrate certain actions. Therefore, all objectives must be described in operational terms such as represented in Table #2. This illustrates
an extensive but not an exhaustive list of behavioral objectives.

At the preliminary stage of program construction, there is a statement of general objective (Appendix D). This statement is then broken down into a series of smaller objectives which specify what the learner will be able to do at each stage of the program. A declaration of detailed objectives, prior to writing instructional material, ensures exclusion of extraneous information and the inclusion of every step and concept necessary towards attainment of the general objective. In summary, programmed instruction is goal-oriented learning to help students acquire specific knowledge or skills.
Note: Objectives state what the student will be able to do or demonstrate after completing a given learning sequence or instructional situation. The objectives define exactly what the student must be able to do to attain the broader goals or understand the topics of the course.
2.52 EFFECTIVENESS OF PROGRAMMED INSTRUCTION

Evidence in the literature indicated that when compared with conventional techniques, programmed materials consistently produced at least equal student performance of learning objectives, often in shorter periods of time. In an analysis of research on instructional procedures in secondary school science, Ramsay and Howe (1969) reviewed 16 reports on programmed instruction and have neatly summarized the results. For reports that show the positive effectiveness of programming to impart content, these authors cite; Besler (1966), Karnes (1966), Darnowski (1968), Sayles (1966), Young (1967), and Zesche (1966).

In addition to imparting content, Young also concluded that students using programmed materials in high school biology reached the same level of achievement as other students in less time. Karnes, reports that higher achievement level is attained when compared with students taught by the traditional methods given equal time. After three years of work with programmed science experiences coupled with student performed activities, Hedges and Mac Dougall (1965) concluded that a programmed approach can be a valuable adjunct to modern school science. The investigators note that this is true in the sense that students become highly motivated over longer periods of time because of the opportunity to proceed at their own rate doing many experiments by themselves.
Another review of the literature conducted by Royce and Shank (1975), summarized the results of 21 research papers on individualized teaching and made conclusions about its usefulness and appropriateness in science education. They indicated that little difference was found for achievement in cognitive objectives, inquiry skills and critical thinking between individualized and group paced instruction when measuring the understanding of science. Similarly, Bard (1975), attempted to develop a programmed, self-paced, variable step guide, and to determine if this was as effective as the traditional textbook method. An analysis of his results for a general science course failed to indicate any significant difference in achievement. Students also preferred the self-paced study and participation in learning activities of small groups over large.

The effectiveness of an entire college science course taught by programmed instruction has been reported by Lagendijk (1978), and Balfour (1978), in separate studies. Both researchers indicated that there was a significant difference in achievement between students in programmed classes and those in conventional laboratory courses. They also found that these students were able to achieve these higher scores in less time. Hedges (1978), while investigating the long term effects of programmed materials,
conculs with the above findings. He also noted that differences in achievement were attributed to the development of better study habits of the experimental students plus a student belief that they can learn more through a programmed instruction.

In a literature search comparing individualized and conventional modes of instruction in science, Marchese (1977) noticed that compared with other educational fields, very little has been reported in science. He criticizes the poor quality of research methods used and only those reports applying acceptable research designs were selected for the review. Marchese, cites Dutton (1963), Peterson (1970), Williams (1969), Leo (1973) and Lewis (1974) as researchers who found that the achievement of students using programmed instructional materials was significantly higher than those taught by conventional methods.

Williams, Leó and Lewis, also reported that not only was achievement higher, but retention was greater. Similarly, students using an individualized approach had a more positive attitude towards the course. A positive outlook towards science education is frequently associated with programmed instruction and acknowledged in other articles by Moriber (1967), Del Barto (1978) and Flowers (1977).
From a different perspective, only one study indicated that programmed instruction was less effective than conventional methods. Eshleman (1967), concluded that in terms of immediate learning and in measures of retention, the conventional method was more effective. Both methods of instruction, however, did produce significant gains in subject knowledge.

As a synopsis of current research related to personalized instruction, Gabel, Kagen and Sherwood (1980), concluded that (p. 456):

1. When methods such as audio-tutorial instruction, programmed instruction and learning activity package are used for instruction, student's attitudes toward the subject and/or method of instruction are generally positive. It is difficult to know whether this effect is stable over time, or due to the novelty of using a new method.

2. Cognitive gains from individualized instruction have been mixed. With audio-tutorial instruction and learning activity packages, cognitive gains are generally reported when the method is used for a small number of units or over a short time span. Cognitive gains for programmed instruction have not been clearly established.

2.6 PROGRESS WITH LIMITED LEARNERS

A report on the effectiveness of programmed instruction with disturbed students was conducted, by Eldred (1966). The main purpose of this research project was to study effects of programming upon the academic, therapeutic and
social progress of children and adolescents in a state mental hospital. It was later expanded to include limited learners or underachievers in a public high school.

Eldred, believed that programmed instruction would provide a sense of worth and academic progress needed to prevent dropouts. Most importantly, he investigated and concluded that many limited learners, regardless of their past experience with school, were able to learn under this system. The results are not perfectly clear as to benefits that the programmed method may provide over conventional teaching methods as there were no significant differences reported.

A research study by Walther (1975), reports on the effectiveness with which the New Educational Program, (a modification and refinement of the Job Corps programmed learning) can provide worthwhile learning experiences for underachieving adolescents. The program success was measured by achievement tests, the quality of participation and other outcomes indicative of success. On average, students gained three-fourths of a grade achievement level in academic skills during three months. Walther concluded that programmed instruction was found to be an effective educational component in a variety of programs concerned with academic underachievers.
There seems to be some discrepancy in the literature regarding limited and more able learners. Hirrel (1971), found that high ability level seventh graders have little need for programmed instruction whereas at lower ability levels, there is a strong need for full employment of such techniques. In terms of immediate learning and retention Eshleman (1967), found significant differences in favor of traditional instruction for below average students when compared with programmed instruction. Arlin and Westbury (1976), reported that student-paced, individualized science instruction using programmed materials resulted in a higher mean learning rate for those students described as being more able of fast learners.

They describe a phenomenon known as the "leveling effect" where teachers tend to focus on the needs of lower-ability students. The teacher's attention, instruction and a press for greater achievement is deflected from more able students by this "steering criterion group". The suggestion is that teacher-paced classroom instruction may significantly effect science achievement by limiting the abler students. The evidence presented in their study indicated that slow to medium learners achieve equally as well through programmed instruction, whereas fast learners increased their learning rate very significantly. The researchers concluded that their finding should be viewed as an indication of the
powerful influence that an instructional methodology may have on all students.

2.70 DESIGNING A PROGRAMMED INSTRUCTION

The following subsections reveal specific research findings related to designing successful programmed materials. As the success of this investigation could be influenced by the quality of an author-designed programmed instruction; it was essential to review articles that examined programming techniques.

2.71 LINEAR PROGRAMS

Morley (1970), reports that 90% of published programmed materials are of the linear format mainly due to their efficacy and simple construction.

A study conducted by Crabtree (1967) on the relationship between scores, time, I.Q. and reading level for fourth-grade students using varied programmed science materials, revealed no significant differences in the mean scores, I.Q.'s or the mean reading levels for any versions, but there was a significant difference in the mean times. By structuring the materials in different ways, linear versions seemed preferable to other program designs since the same amount of material was covered in less time. It was noted that those students who took less time to work
through linear programs tended to earn higher scores than those on other versions, even after I.Q. and reading level differences have been eliminated. This would indicate that time and score are not related. Crabtree explains the oddity by suggesting that the closer supervision of students using programmed materials was needed.

2.72 CONCRETE MATERIALS

Programmed instruction in science does not rule out that laboratory activities such as experiments can be made an integral part of the program, if they are highly structured. In a study by Nasca (1965), an attempt was made to determine how active involvement in learning scientific principles influences some specific student abilities. The student's involvement was assured through the use of programmed materials accompanied by three methods of acquiring scientific evidence to support new principles developed in the program.

The three methods of providing supplementary evidence were; seeing a teacher demonstrate 73 activities, personal active performance, and reading about new concepts. The results indicated that active participation in obtaining supportive evidence for scientific principles was significantly superior. The other two independent variables were about equal. Nasca, suggests that a programmed in-
struction may be accompanied by a variety of materials supporting the verbal behavior being developed. Statements within a program could direct students to participate in any number of activities related to the topic. Therefore, concrete materials could be used to support new concepts presented in the program.

2.73 ADVANCE ORGANIZERS

In an experiment designed to investigate individual differences in learning from programmed materials, Koran and Koran (1973) preceded the materials with advance organizers. The purpose of an advance organizer is to provide some structure or "general idea scaffolding" into which new concepts can be incorporated. It has been reported that limited and more able students benefit from this technique. Zeaman and House (1967), suggest that if lower ability students are weak in attentional and discriminational skills, the structure provided by advance organizers may compensate for this lack by means of attention directing and controlling features.

The results of the experiment conducted by the Korans, did not find any significant difference in using advance organizers before programmed materials. They suggest that this effect may be attributable to the fact
that programmed instruction itself, with accompanying feedback following each frame, provided sufficient structure to serve the needs of limited learners.

2.74 VISUAL ILLUSTRATIONS

Dwyer (1972), reports that research has found that all types of visual illustrations are not equally effective in complimenting programmed materials. One of the reasons cited for the phenomenon is that additional stimuli contained in more realistic illustrations tends to distract a student's attention from the relevant learning cues.

The purpose of Dwyer's study was to determine which types of visual illustrations used with programmed instruction were most effective in facilitating student achievement. Specifically, eight types of visuals were used to determine their relative effectiveness. The amount of time students study their respective programs and the influence of color in visual illustrations was simultaneously explored as instructional variables for promoting student achievement.

The results indicated that all types of visuals are not equally effective. An increase in the amount of realistic detail in illustrations will not arbitrarily improve student achievement. Dwyer's suggestion, agrees with current opinions that illustrations presented as
simple line drawings (in color) are the most effective for increasing student achievement. Success of simple line drawings may be attributed to the fact that students could readily identify relevant instructional cues in the diagrams and learn from them.

2.75 INDUCTIVE AND DEDUCTIVE PROGRAMS

In a comparison of inductive and deductive programmed materials, Sakmyser (1974), found no significant difference between the type of program used when teaching chemical equilibrium to high school chemistry students. Similarly, there was no significant difference on the student's retention tests. However, each program had specific benefits for individuals with certain personality traits or skills.

For example, reading ability had little effect on the student's inductive program performance but those students with lower reading ability were less successful on the deductive program than students with higher reading ability. This difference may be explained by the fact that the deductive program required students to read and comprehend large principles all at once at the start. The inductive program, requires comprehension of small pieces of knowledge building towards larger concepts. The implication drawn from the study indicates that programmers should follow an inductive programming scheme to minimize
difficulties in reading abilities.

The above research is in agreement with earlier work by Theofanis (1964), who compared two programs, one written inductively and the other deductively while covering the same topic. When investigating the correlation between instructional base and student mental ability, he found that students of low and high mental ability learned better inductively. The average students showed no significant difference between the two methods.

2.76 SPECIFIC REVIEW AND QUESTION COMPLEXITY

When comparing specific review against repeated presentations, Merrill (1970), concludes that when coupled with a correction procedure, the specific review technique increased learning efficiency. Apparently, receiving the review immediately following a series of presentation frames was better than having to wait for a criterion measuring question. It was also reported that a summary presented at the end of a sequence increased student confidence in the materials as they tended to spend more time with subsequent frames.

A study entitled, "The effect on learning of post-instructional responses to questions of differing degrees of complexity", has been researched by Yost, Avilla and Vexler (1977). Their purpose was to determine the effect
on learning science content by having students overtly respond to questions of different complexity following segments of programmed materials. Those subjects who completed the program by responding to interspersed questions scored significantly higher than those who completed the program with covert responses. This phenomenon occurred regularly when a technical or specialized vocabulary was used with a time delay between the instruction and the criterion measure.

These authors suggest that as complexity of questions increases, achievement increased as did amount of time spent on the program. They therefore concluded, that by asking more complex questions as part of the instructional sequence, higher relevant and incidental achievement occurred. This greater achievement was related to the additional experience of practise students obtained through inspection behaviors. (i.e. rereading, sorting, examining, and looking for other stimuli).

Yost, Avilla and Vexler, note the need for a greater understanding of the relationship that exist between characteristics of questions used to elicit student responses and the amount of learning that occurs from those responses. They also report the work of Fraser (1970), and Rothkopf (1966), that questions placed either before or after an instructional sequence have in general, produced facilita-
tive effects on learning.

2.8 PLACE IN CURRICULUM

Personalized instruction provides an efficient method of learning specific content outcomes and has a definite place in science education, but what that actual place in the total instructional scene is not completely clear. Ramsey and Howe (1969), found that research has been largely preoccupied with the nature of the effectiveness of individual programs rather than how these may best be applied in school situations. They suggest that each individual teacher and each school should make some evaluation on the role of personalized instruction, perhaps contributing to the meagre literature on its effective utilization in the classroom.

Morrow (1965), also states that programmed materials will definitely serve a purpose in the school system. He suggests their greatest value would be as supplementary materials in a regular classroom situation. Specific programs could be designed to expand on a single concept, presented in a textbook, for the benefit of more able students. Other programs could be written for limited learners, giving them a "slower pitch" on some elusive topic. Morrow, summarizes that programmed materials should supplement, as enrichment for the able student and assistance for the slow learner, rather than replace present instructional materials.
Similarly, Roucek (1969) suggest that personalized instruction be gradually introduced and used for specific purposes. These include developing short units to complement, extend, remedy, and review other instruction modes. The flexibility of this technology allows slower students additional time for review whereas faster students can either work in greater depth or explore new areas of interest.

Often in the past, words like "programmed instruction" or even worse, "teaching machines" have conjured up erroneous notions about a package deal of instant education. Eldred (1966), sarcastically stated that you just add a student, let simmer for two semesters and presto.... an instant scholar!

This is not true as these programs will be most effective when used by an experienced teacher with adequate training and related background. It is not to disparage the claims of programmed instruction notes Eldred, but valuable learning can best occur using it in one small subject area by one highly motivated individual. He recommends that teachers use this technology as an aid to personalize education.

A similar comment is reported by Blake and McPherson (1969), to clarify an important point. They write that children cannot learn effectively via individual instruction
by simply being told to proceed at their own pace through the study of traditional materials. Specially prepared materials are required at the beginning of the subject and should proceed sequentially until a required level of competence has been completed.

Programmed instruction will not replace the classroom teacher, dehumanize learning, or increase the teacher's workload. Blake and McPherson, reported that programmed instruction can actually enhance learning. They predicted that the technique will free teachers for various neglected dimensions of teaching (i.e. by leading discussions, raising challenging questions, diagnosing, working with individuals, conferences, examining alternate materials, planning, and listening to students).

Sheehan and Hambleton (1977), state that no single instructional process provides optimal learning for all students. Given predetermined educational goals, some students will be more successful with one program whereas others are more successful with different methodologies. The teacher is not isolated from a student's progress, as programmed instruction provides two constant gauges on learning activities. The number of errors and relative position in the program indicates areas of difficulty or ease of progress and allow alternate planning of learning experiences to clarify situations.
Programmed learning should not be allowed to set the class scene or dictate teaching methods. Morrow (1965), agrees that programmed instruction is a bright tool whose uses and limitations must be cautiously defined. Similarly, Hedges and MacDougall (1965), have serious reservations about programmed materials constituting the totality of any school science program. They suggest a variety of ways in which short programmed units can become another facet of the balanced science program in a modern school.

Studies conducted by Woodruff (1965), and Sayles (1966), indicated that students enjoy the novelty of programming but can soon tire of it when used to excess. Therefore, an attitude problem could develop if this was the only or primary instruction mode.

Most science courses already programmed seem to be concerned with subject matter outcomes, these being verbal in nature. Techniques have apparently not been devised as yet for attaining the broad goals of science education. (i.e. scientific attitude, processes of science, etc.) Therefore teachers should be cautious in employing programmed materials other than to supplement regular classroom procedures.
2.90 IMPLICATIONS FROM RESEARCH

After summarizing research results (Table 4), the author considered the following suggestions when writing the program. An extensive effort was made to write with an appropriate reading level as it tends to provide the greatest "stumbling block" to underachievers. The format of the program was linear and followed an inductive approach to learning.

The presentation of an advance organizer may help some students conceptually arrange the new material. Visual illustrations in the form of simple line drawings were a valuable asset in clarifying certain ideas, instructions, and information. A provision was incorporated for alternative activities that included concrete materials to reinforce verbal behaviors and skills being taught. Ideally, personalized instruction could aid as an important supplement to routine classroom procedures adding variety to meet the required needs of each student. Personalized instruction is not a panacea for all education. Astute observers have recognized both the positive attributes as well as some negative comments in the literature.
### TABLE 4

**SUMMARY OF RESEARCH:**

<table>
<thead>
<tr>
<th>AUTHOR(S)</th>
<th>PROGRAMMED RESEARCH AREA</th>
<th>IMPLICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bard, Ramsey and Howe</td>
<td>General effectiveness</td>
<td>-equally successful as traditional teaching</td>
</tr>
<tr>
<td>Barry</td>
<td>Advanced content</td>
<td>-senior content can be designed for junior students</td>
</tr>
<tr>
<td>Crabtree</td>
<td>Linear programs</td>
<td>-linear programs are more efficient</td>
</tr>
<tr>
<td>Dwyer</td>
<td>Visual illustrations</td>
<td>-simple line drawings are most effective</td>
</tr>
<tr>
<td>Eldred, Walther</td>
<td>Limited learners success</td>
<td>-increased achievement for underachievers</td>
</tr>
<tr>
<td>Koran and Koran</td>
<td>Advance organizers</td>
<td>-some form of mental framework may help certain students prepare for a program</td>
</tr>
<tr>
<td>Merrill</td>
<td>Review characteristics</td>
<td>-present a summary after a short sequence</td>
</tr>
<tr>
<td>Morrow</td>
<td>Place in curriculum</td>
<td>-as a supplement to regular procedures</td>
</tr>
<tr>
<td>Nasca</td>
<td>Concrete materials</td>
<td>-include lab activities to reinforce new scientific principles or concepts</td>
</tr>
<tr>
<td>Sakmyser</td>
<td>Inductive and deductive programs</td>
<td>-inductive programs favourable for limited learners or those with lower reading ability</td>
</tr>
<tr>
<td>Arlin and Westbury</td>
<td>Leveling effect</td>
<td>-bright students increase learning rate significantly</td>
</tr>
<tr>
<td>Yost, Avilla and Vexler</td>
<td>Question complexity</td>
<td>-overt responses to complex questions increased achievement and higher concept development</td>
</tr>
</tbody>
</table>
CHAPTER 3.

DESIGN AND METHODOLOGY

3.0 INTRODUCTION

The following chapter describes the course of action taken to answer the research questions. It covers: the background of the participants, a detailed description of how the limited learners were identified, the materials and instruments employed with the chosen design and concludes with previous pilot study results.

The impetus for conducting this investigation was to explore the success of programmed materials for limited learners in a regular classroom.
3.1 DESCRIPTION OF SAMPLE

The students involved in this study were enrolled in a regular science eight program at Killarney Secondary School, in District #39, Vancouver. For most of these students, this was the first year of secondary education encompassing grades eight through twelve. The students came from a wide range of socioeconomic backgrounds, including several single-parent and immigrant families.

At Killarney, students are heterogeneously grouped and assigned to classes by a computer program which is considered to be equivalent to random selection. However, a small group of limited learners (13 students) was previously screened from the population and placed in a "Basics" program. This special group were not selected for the study, as the research question examines the relative performance of limited learners within a regular classroom situation.

A total of five clusters of science eight classes (approximately 120 students) were selected from a grade eight population of 310 students. The actual number of students who participated in the study was 116. Four students were not included due to extended illnesses when either the pretest or posttest was written.
TABLE 5

Characteristics of the Five Cluster Samples

<table>
<thead>
<tr>
<th>Class</th>
<th>Size</th>
<th>Normal Learners</th>
<th>Limited Learners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1**</td>
<td>15</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>2*</td>
<td>24</td>
<td>21</td>
<td>3</td>
</tr>
<tr>
<td>Teacher 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3**</td>
<td>29</td>
<td>24</td>
<td>5</td>
</tr>
<tr>
<td>4*</td>
<td>25</td>
<td>21</td>
<td>4</td>
</tr>
<tr>
<td>5*</td>
<td>23</td>
<td>19</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>116</td>
<td>97</td>
<td>19</td>
</tr>
</tbody>
</table>

*experimental treatment (n=72)
**control groups (n=44)

Cluster sampling assumes that all members of the selected groups have similar characteristics (Gay, 1976). This means that rather than randomly selecting grade eight students, entire classrooms are randomly selected and all students in the selected classrooms participate in the study. Therefore, some confidence must be placed in the school's class selection format. Cluster sampling increases the chances of obtaining administrative approval due to selecting intact classes rather than randomly selecting and removing a few students from each class. One drawback to cluster sampling is selecting a sample which is not representative, in some way, of the population. This was compensated for by selecting a larger sample (five clusters) rather than one cluster.
The five science eight classes were taught by two male science teachers, with the study carried out during the winter term in January, 1982. This allowed the previous months of "acclimatization" for these new students to adjust to a large secondary school system. A previous survey had indicated that most students had little or no experience with programmed instruction. Therefore, it was assumed that there were no confounding effects due to previous learning experiences. The treatments were randomly assigned to the classes so that each teacher had at least one experimental and one control group.

3.2 SCHOOL AND TEACHER BACKGROUND

Killarney Secondary School is located in south-east Vancouver. The school population was 1665 students with a complement of 88 staff members. The science eight program was a semstered course involving five classroom periods of 59 minutes each, in seven school days. Although the time allotment was below the provincially recommended guidelines of 110 hours per subject, Killarney students receive approximately 130 hours of science instruction per year in both grades nine and ten. The school administration is aware of these discrepancies and timetables are being changed in September 1982.

One of the science teachers in this study has been teaching for 29 years in Vancouver at both the elementary and
secondary levels. For over the last 15 years, this instructor has been employed at Killarney, working exclusively with the junior science program. The teacher does not recall instructing with programmed materials at any time in his career but appeared to show a genuine, professional interest in being part of this investigation.

The author, who was the second teacher, had taught junior science at Killarney for five years. This experience includes three years of instructing limited learners in specially modified science classes. Both instructors followed similar approaches in their traditional instruction, (as defined in section 1.11) and identical approaches with the programmed instruction. Daily conferences were held between the two teachers to ensure that they fulfilled similar instructional techniques. At these meetings, films were exchanged, laboratory activities and the student's progress were discussed along with any problems encountered. Both science teachers have taught the current program eight times in the previous four years.

3.30 IDENTIFICATION OF THE LIMITED LEARNERS

A crucial stage in the investigation was the appropriate designation of those subjects deemed as limited learners. The literature indicates that the proposed sample would probably include 18 to 24 limited learners, in a population of 120 subjects (see section 1.2). Since a small group of the
total population had been placed in the "Basics" program, the sample was likely to contain 14 to 20 limited learners. In final selection, 19 students were identified as limited learners.

To identify students as limited learners, four criteria were used. They were:

1. Canadian Test of Basic Skills (C.T.B.S.) results
2. grade seven final science letter grade
3. science eight first term letter grade
4. District Science Survey examination score

Using a combination of these assessments, the limited learners were considered as those subjects who had consistently achieved low grades in science during grades seven and eight and were presently experiencing limited academic success. Each one of the four criteria is clarified in the following subsections.

3.31 FORMER EVALUATION

Each student's permanent record card was reviewed to provide a grade seven final science evaluation. This letter grade yielded a recent performance level of science achievement.

The C.T.B.S. was administered in the spring of 1981 to 101 of the subjects proposed for this study. Scores were not available for 15 students who recently moved into this area from outside regions or did not write the examination. These
students were therefore identified as being limited or normal learners on the three remaining criteria. Of the 15 students, only one was identified as a limited learner.

The C.T.B.S. represents an appropriate assessment of comprehension in four areas of evaluation: vocabulary, reading, math concepts and math problems. These C.T.B.S. tests are constructed to facilitate individual testing of pupils, at different levels of development, in the same classroom. The range of difficulty in the test items provides a maximum efficiency in discriminating over the entire range of achievement in the grade. (King, 1977).

The C.T.B.S. results were recorded as stanines with the lowest four stanines corresponding to letter grades of C-, D, D- and E. Those subjects whose four stanine scores total 13 or less were considered limited learners in this study. Of the 116 students in the sample, 18 were identified as limited learners by the C.T.B.S. results.
Table 6

C.T.B.S. Total Scores

<table>
<thead>
<tr>
<th>Score Interval</th>
<th>Frequency</th>
<th>Cumulative Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5-7</td>
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<td>8-10</td>
<td>6</td>
<td>7</td>
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<tr>
<td>11-13</td>
<td>11</td>
<td>*18</td>
</tr>
<tr>
<td>14-16</td>
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<td>36</td>
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<td>17-19</td>
<td>13</td>
<td>49</td>
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<tr>
<td>20-22</td>
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<td>64</td>
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<td>23-25</td>
<td>17</td>
<td>81</td>
</tr>
<tr>
<td>26-28</td>
<td>10</td>
<td>91</td>
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<td>29-31</td>
<td>7</td>
<td>98</td>
</tr>
<tr>
<td>32-34</td>
<td>3</td>
<td>101</td>
</tr>
</tbody>
</table>

*identified as limited learners

3.32 CURRENT EVALUATION

As the research was conducted in January 1982, all students had received one of the two letter grades earned for the semestered course. This gave some indication of the immediate level of progress at which each student was developing in the new environment.
The Vancouver School Board Program Resources Department conducted a survey of science achievement among grade eight students in Vancouver schools in June 1980. A total of 2643 students took part in the survey which was designed to assess the degree to which curriculum objectives were being attained in the current program. The survey instrument was based on the science eight curriculum and contained 15 general science multiple-choice items.

The latter multiple-choice items were written by all subjects to assess their performance in the areas of: safety, metrics, scientific method, simple formula calculations and interpretations of graph or lab data. A distribution of achievement scores for students who wrote the general section provided median and mean scores, a standard deviation plus a cumulative percentage of student scores.

Of the 2580 students who wrote the subtest, 18% scored five or less out of a possible 15 responses. In this study, 33 of the 116 students in the sample who achieved a score of five or less on the general science survey were considered to be possible limited learners.
Table 7.

V.S.B. Science Survey Results

<table>
<thead>
<tr>
<th>Score Interval</th>
<th>Frequency</th>
<th>Cumulative Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2-3</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>4-5</td>
<td>23</td>
<td>*33</td>
</tr>
<tr>
<td>6-7</td>
<td>26</td>
<td>59</td>
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<tr>
<td>8-9</td>
<td>31</td>
<td>90</td>
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<tr>
<td>10-11</td>
<td>16</td>
<td>106</td>
</tr>
<tr>
<td>12-13</td>
<td>8</td>
<td>114</td>
</tr>
<tr>
<td>14-15</td>
<td>2</td>
<td>116</td>
</tr>
</tbody>
</table>

*identified as limited learners

For the purpose of this investigation, a student identified as a limited learner must meet the criterion in at least three of four defining characteristics. In summary, the limited learners were identified as those subjects who:

1. in grade seven achieved low science grades (C-, D and E)
2. in grade eight achieved a low first term science grade
3. scored a stamina total of 13 or less on the four C.T.B.S. subtests and
4. achieved a score of five or less on the general science survey.
3.40 INSTRUMENTATION

To assess achievement in general science concepts, an examination was constructed by the investigator which contained 30 multiple-choice items referenced to the contents of the programmed instruction. The test items were then compared with the material covered in the traditional approaches. Content validity was established by having both teachers agree that the test items were reasonable with respect to the material covered in the programmed and traditional instruction. A copy of the test is included (Appendix B).

The author-developed test was used as a pretest and posttest to measure gains in achievement. Although identical items appeared on both tests, a diverting reconstruction was attempted on the posttest. The sequence of test items was randomly jumbled and the posttest printed on a different color of paper to create an illusion of a different test, to reduce errors of test-retest sensitivity and improve internal validity of the study.

Taking a pretest may improve performance on a posttest, regardless of whether there is any treatment or instruction in between (Gay, 1976). This threat to internal validity is more likely to be a problem when time between testing is short or when tests measure factual information which can be recalled.
3.41 THE PROGRAMMED BOOKLET

At present, there is no readily available programmed instruction that corresponds with the prescribed curriculum for the science eight syllabus in B.C. Therefore, the programmed booklet used for the study was designed by the author (outside of this investigation) for all students enrolled in grade eight. The booklet was written to accommodate limited learners by using language at an appropriate level combined with repetition of core curriculum concepts for the topic of LIGHT. Basic skills such as completing diagrams, following instructions, inferring and reviewing previous questions incorporated.

The student's booklet contained 90 frames of information, questions, concepts, challenges and 17 opportunities for alternate activities. A brief explanation for other teachers was also included covering the purpose, content, activities, some programmed instructional theory, suggestions for the implementation and use of the material. The booklet was written in behavioral terms with at least one item to cover each of the unit objectives (Appendix D). The alternate activities help to achieve these objectives by reinforcing the learning process.

The author of the current science eight textbook on LIGHT, Mr. John Petrak, provided constructive criticism and suggestions
for improving the entire instructional unit. Revisions of the first draft included:

1. providing more multiple-choice items, (a or b type)
2. attractively spacing each frame and response,
3. focusing on the key idea being presented,
4. offering a variety of alternate activities.

The booklet was presented to Mrs. Jackie Eccles, a reading specialist employed by the Vancouver School Board. She conducted a readability test, using the formula developed by Edward Fry (known simply as the Fry Readability System). Two random samples were analyzed to be at the grade seven and grade two reading levels, respectively. Other comments were that the simple sentences, easy vocabulary and an attractive format with good spacing would increase success for poorer readers.

The illustrations, taken mainly from the science eight textbook are clear and uncluttered. Permission to use these diagrams was obtained from the editor, Mr. Manfred Schmid. These diagrams correspond to simple line drawings that current research literature (Dwyer, 1972) indicates is most effective for increasing student achievement.

3.42 OPINIONNAIRE

To obtain some general information on student attitudes towards programmed instruction, an opinionnaire was developed by the author to reveal the students' reactions. It was
assumed that if the subject's name did not appear on the survey sheets, there would be increased validity in the responses. Students were encouraged to display their actual feelings towards the methodology as sincerely as possible in a classroom situation.

3.43 ADMINISTRATION

The pretest was written in conjunction with the 15 item multiple-choice general science survey, before beginning the new unit, LIGHT. This was more convenient than writing two tests at different intervals. The students were shown the correct procedure for recording answers on computer cards to facilitate marking.

The computer cards were checked for clerical errors before marking (appropriate darkness, sloppiness, etc.). As a further check against errors, the posttest answers were also written on paper and subsequently marked by hand. There were few deviations in achievement scores from the computer scores amounting to increasing and decreasing some scores by one or two marks. Writing time for the posttest was some 45 minutes.

The experimental groups were told that they are being taught by a different mode, programmed instruction, to determine if it was a worthwhile method for learning science. The LIGHT unit of the science eight program would "count" just as much as other topics towards their final letter grade. The students were reminded that they were accountable for anything in the
programmed booklet and would write an important, comprehensive, final exam on the material covered. The posttest was written as a standard classroom exam when all subjects had completed the unit.

It was assumed that the above strategy would eliminate a "just-for-fun" attitude that some pupils acquire when trying something new and increase the seriousness of student participation in the study. However, the halo or Hawthorne effect may be present with some if not most students. The opinionnaire was administered one week after the posttest. This allowed time for some reflection and a better comparison with the traditional approach.

In the investigation, all subjects were studying the topic, LIGHT, at the same time. Those using programmed instruction completed the booklet in two weeks (10 to 12 hours) depending upon the amount of time spent on laboratory activities. The students following the traditional approach required more time (2 hours) to cover the same amount of material. The posttest was written as a group after all members of one specific group had completed their instruction. Those students who completed the programmed instruction before other students were encouraged to explore other areas of interest related to LIGHT in their readers. (i.e. lasers, telescope functions, lenses, mirages, etc.).
All subjects absent for one or more periods during the study were required to work for an equivalent interval on their own time before writing the posttest. This was arranged with each teacher for early morning, lunch time, after school or as home study assignments. The teachers organized materials for absent students in the traditional setting when they returned, whereas a positive feature of programmed materials is their flexible use in scheduling, requiring minimal preparation.

3.5 DESIGN OF STUDY

A 2 X 2 X 2 quasi-experimental fixed effects factorial design with a repeated measure on the third factor was used in this study. Campbell and Stanley (1963), outlined a non-equivalent control group design that was followed to test the null hypotheses between the means of limited learners, normal learners and the interaction of learning ability with programmed and traditional instruction.

The first factor (Factor A), the type of instruction has two levels, programmed and traditional. The second factor (Factor B), learning ability has two levels, limited and normal. The limited and normal learners were defined in sections 1.13 and 1.14 respectively. The third factor, (Factor C) achievement has two levels, pretest and posttest scores which serve as a repeated measure.
An illustration of this design is drawn below with the size of each cell sample.

Figure 1

Cell Sizes in Factorial Design

The reason for selecting this design was to determine whether the effects of the experimental variable (programmed instruction) were generalizable to all levels of the control variable (learning ability) or whether the effects were specific to certain levels of the control variable. By using a factorial design, there was a chance to determine if an interaction exists between the variables such that each instruction method was differentially effective depending upon the learning ability of the students. Factorial designs permit simultaneous testing of numerous hypotheses and provide answers to a number of questions within the framework of a single experiment.
3.6 DATA ANALYSIS

The pretest was initially used to determine if the cluster samples were the same on the dependent variable. If the results were similar, posttest scores could be directly compared using an analysis of variance. Since the cluster samples were not similar (random assignment does not guarantee equality), the posttest scores were analyzed using an analysis of covariance. Covariance adjusts the posttest scores for initial pretest differences.

The most appropriate way in which data can be analyzed for factorial design interactions is simply to compare posttest mean scores of the two groups with the treatment. However, since the pretest results for each group were different, the posttest results were adjusted. By using the same items on the pretest and posttest, gains in achievement were determined for each group. The mean scores and standard deviations were calculated for all subjects writing both tests. To display the raw score data, a frequency polygon was constructed to compare the pretest and posttest scores. An item analysis of the measuring instrument was conducted to determine the difficulty and discrimination indexes for each test item and a reliability coefficient (Appendix C).

3.7 PILOT STUDY RESULTS

A pilot study using similar instruments was conducted with a regular science eight class in March 1980. The group
of 29 students contained five limited learners as indicated by previous achievement and letter grades. Classroom observations revealed that most pupils successfully completed the booklet in two periods as no lab activity was involved. An average student required 1.5 hours of continuous work to finish the program. This implied that a revision of the original program should be undertaken before implementation as a complete unit for grade eight students.

During the first booklet sessions, there was a definite atmosphere of diligent student application within the classroom. Fewer than usual classroom disturbances were noted as each student was keen to work independently. The Hawthorne effect could be one explanation for these conditions. As a classroom activity, programmed instruction was a successful tool in controlling undesirable behavior while productive, genuine learning appeared to be occurring.

The statistical results from an examination showed the mode and median score both at 41 out of 50, whereas the mean score was 39. The range of scores went from 20 to 48. The high scores on this cognitive evaluation indicated that a desired core or basic comprehension level could be achieved for all students including limited learners. An average student was very proficient (80%) in answering all test questions while three of the five limited learners achieved scores higher than 50%.
An attitudinal evaluation provided a most interesting section of the pilot study. From a student's viewpoint, programmed instruction is not currently used as a classroom activity. Most students (81%) were in favor of and would enjoy working on a similar instruction booklet at least once a month. When contrasted with other common classroom activities, this learning methodology seems very effective and practical. The results suggested that there should be greater research done and intense curricular development of various programmed instructional units for science education.
CHAPTER 4

ANALYSIS OF DATA

4.0 INTRODUCTION

The results of the analyses described in the last chapter (section 3.6) are presented in this chapter. An overview of the general achievement test results are displayed first to provide a background of information for the total sample. Four distinct groups (learning ability X mode of instruction) were then examined and by using the pretest as a covariate, an analysis of covariance was generated. The chapter concludes with a summary of a qualitative attitudinal survey in which the students were encouraged to express opinions on the experimental teaching method.
4.1 GENERAL ACHIEVEMENT RESULTS

To obtain an overview of the general achievement results for the total sample, two frequency polygons have been constructed for the pretest and posttest. In figure 2, the raw data for the pretest is displayed for all 116 participants in the study. The pretest mean score was 14.88 (out of a possible 30) with a standard deviation of 3.71. The raw data for the posttest is displayed in figure 3, yielding a mean score of 20.86 and a standard deviation of 3.47.

In general terms, there was an overall increase in achievement as measured by these instruments. The average gain in achievement scores for all students in the investigation was 5.98. A summary of these results is displayed in table 8.

Table 8.

<table>
<thead>
<tr>
<th>General Summary of Achievement Tests</th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>14.88</td>
<td>20.86</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>3.71</td>
<td>3.47</td>
</tr>
<tr>
<td>Range</td>
<td>4-27</td>
<td>7-28</td>
</tr>
</tbody>
</table>
Figure 2

Pretest Score Distribution (n=116)

\[ \bar{X} = 14.88 \]
\[ s = 3.71 \]

Figure 3

Posttest Score Distribution (n=116)

\[ \bar{X} = 20.86 \]
\[ s = 3.47 \]
Each one of the factor levels: traditional instruction, programmed instruction, normal learners and limited learners also yields a general mean for the distinct group. In terms of learning ability, the 97 normal learners scored a mean of 15.45 on the pretest and 21.55 on the posttest. The 19 students identified as limited learners scored 11.94 and 17.37 as pretest and posttest means respectively.

When only the methods of instruction are compared, the 44 students taught by traditional instruction scored a mean of 14.13 on the pretest and 19.57 on the posttest. The 72 students taught by the experimental mode, programmed instruction, scored a pretest mean of 15.33 and 21.65 on the posttest.

The largest gain in achievement scores of 6.32 was realized by students using the programmed instruction. Traditional instruction produced an average gain in achievement scores of 5.44. The smallest gain in mean achievement scores for a distinct group was 5.43 obtained by the limited learners. Normal learners increased their mean achievement score by 6.10. A summary of these results is displayed in table 9.
Table 9

General Summary of Distinct Group Means

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Pretest</th>
<th>Posttest</th>
<th>Difference</th>
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</thead>
<tbody>
<tr>
<td>Grand Mean</td>
<td>116</td>
<td>14.88</td>
<td>20.86</td>
<td>5.98</td>
</tr>
<tr>
<td>Normal Learners</td>
<td>97</td>
<td>15.45</td>
<td>21.55</td>
<td>6.10</td>
</tr>
<tr>
<td>Limited Learners</td>
<td>19</td>
<td>11.94</td>
<td>17.37</td>
<td>5.43</td>
</tr>
<tr>
<td>Traditional Instruction</td>
<td>44</td>
<td>14.13</td>
<td>19.57</td>
<td>5.44</td>
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<td>Programmed Instruction</td>
<td>72</td>
<td>15.33</td>
<td>21.65</td>
<td>6.32</td>
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</tbody>
</table>

4.2 ANALYSIS OF CELL SAMPLES

A model of the design used in this study was drawn in section 3.5 as figure 1. Each factor, learning ability and the method of instruction had two separate levels. The mean scores in achievement were calculated as pretest results for each group. Following the application of different treatments, mean scores in achievement were obtained from the posttest results.

The greatest posttest mean score of 22.10 was realized by the normal learners using the programmed instruction. Normal learners following a traditional approach were next with a posttest mean score of 20.61. The limited learners on the programmed method obtained a posttest mean of 19.18 whereas those receiving traditional instruction had a mean score of 14.88 on the posttest in terms of achievement.
When the differences between posttest and pretest mean scores are considered as gains in achievement, a new group order develops. The limited learners taught by the programmed instruction had the greatest increase of 6.45 in mean score achievement gains. The normal learners using this experimental method had an average gain of 6.30 in achievement posttest scores. The smallest gain in achievement scores of 4.02 was obtained by the limited learners following a traditional method of instruction. Normal learners receiving traditional instruction obtained a gain of 5.75 in mean score posttest achievement. A summary of these results is displayed in table 10.

Table 10

Summary of Cell Sample Means (standard deviations)

<table>
<thead>
<tr>
<th>Learning Ability</th>
<th>Instruction Method</th>
<th>n</th>
<th>Pretest</th>
<th>Posttest</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Traditional</td>
<td>36</td>
<td>14.86 (4.12)</td>
<td>20.61 (3.28)</td>
<td>5.75</td>
</tr>
<tr>
<td></td>
<td>Programmed</td>
<td>61</td>
<td>15.80 (3.69)</td>
<td>22.10 (3.63)</td>
<td>6.30</td>
</tr>
<tr>
<td>Limited</td>
<td>Traditional</td>
<td>8</td>
<td>10.86 (2.89)</td>
<td>14.88 (3.95)</td>
<td>4.02</td>
</tr>
<tr>
<td></td>
<td>Programmed</td>
<td>11</td>
<td>12.73 (3.16)</td>
<td>19.18 (3.95)</td>
<td>6.45</td>
</tr>
</tbody>
</table>
4.3 ANALYSIS OF COVARIANCE

The pretest was initially used to determine the equivalence level in achievement scores before the application of treatments. By implementing the same measuring instrument as the posttest, gains in achievement were recorded for each cell sample. In order to determine whether the differences in mean score achievement on the posttest were due to learning ability or the methods of instruction, a 2 x 2 x 2 fixed effects analysis of covariance was performed using the pretest as the covariate.

The analysis of covariance was conducted at the Educational Research Service Centre (ERSC) using the Statistical Package for the Social Sciences. The level of significance used for all analyses was the 0.05 level. The results of the analysis are displayed in table 11.

The analysis of covariance yields significant differences for the two main effects. In terms of learning ability, the normal learners achieved higher than limited learners and the difference was significant at the 0.05 level. For the methods of instruction, students using programmed instruction scored significantly higher than those students taught with the traditional approach. The posttest achievement means corresponding to these factors were previously displayed in table 10.
Table 11

Summary of Analysis of Covariance of Achievement Posttest Scores

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>D.F.</th>
<th>Mean Squares</th>
<th>F</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covariate</td>
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<td></td>
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<tr>
<td>Pretest</td>
<td>1</td>
<td>730.282</td>
<td>84.929</td>
<td>0.000</td>
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<tr>
<td>Main Effects</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Learning Ability (LA)</td>
<td>1</td>
<td>70.532</td>
<td>8.203</td>
<td>0.005</td>
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<tr>
<td>Instruction Mode (IM)</td>
<td>1</td>
<td>50.731</td>
<td>5.900</td>
<td>0.017</td>
</tr>
<tr>
<td>2-Way Interaction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LA X IM</td>
<td>1</td>
<td>20.937</td>
<td>2.435</td>
<td>0.122</td>
</tr>
<tr>
<td>Residual</td>
<td>111</td>
<td>8.599</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>115</td>
<td>15.876</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To determine if the programmed or traditional instruction was significantly different for a particular group of students (in terms of learning ability), a 2-way interaction was performed. At the 0.05 level of significance there was no interaction between learning ability and the methods of instruction.

A graphical analysis of the interaction was constructed for a better interpretation of the result. In figure 4, the mean scores of the achievement posttest results were plotted against the instruction mode. The graphical analysis reveals a trend but there is no statistically significant interaction between learning ability and mode of instruction with respect to achievement on the posttest scores.
4.4 ATTITUINAL SURVEY ANALYSIS

The attitudinal survey was conducted to obtain further background information on the student's experience with programmed instruction and to provide a qualitative evaluation of the experimental methodology. The results were based on a sample attitudinal survey (Appendix A). The totals were converted to a percentage for the ensuing discussion.

The survey indicated that 58% of students in the experimental group claim to have never or were not sure if they had ever worked on a programmed instruction task before. In determining how useful the booklet was in helping students to learn about Light, 30% replied with, "very helpful" while 98% responded in the combined categories of, "helpful" and, "very
helpful". This figure corresponds with another question regarding the value of the programmed booklet. Only 2% reported that it was, "useless" or of, "no value".

As a classroom activity for one period, 26% of the students surveyed rated it as being, "very good". The majority (66%) claimed the activity was, "average" whereas 8% thought it was, "boring". When asked how often students would want to work on a programmed unit, 80% suggested at least, "once a month" or more frequently while the majority (50%), desired to work on programmed instruction, "once a week".

An attempt was made to rate programmed instruction qualitatively with nine other methods of instruction. The most popular activity selected by the students was to, "watch a film" on the topic under study. The next most desirable methods were: to, "do an experiment themselves, watch the teacher perform a demonstration" and start, "a programmed booklet". Activities that were rated less desirable than working on a programmed instruction were: to, "write out notes, work on practise problems, listen to the teacher talk, begin a library project, write a test and read from a textbook."

When asked for what main use could be made of a set of programmed booklets, 49% of the students thought that the best use would be in, "reviewing for a test". A substantial group (40%), indicated that they would use programmed book-
lets to, "locate information on topics that were not clearly understood in class". Only a small group of 11% thought that they would use programmed instruction for, "advanced learning into other topics" or as a, "general study method for daily assignments". On another question, 62% of the students indicated that they, "would like to study another unit of science by using only programmed instruction".

The booklet was not thought to be more, "tiring" by 85% of the students, than a normal class. To describe the booklet in other terms, 40% described programmed instruction as, "fun or easy", 62% rated the booklet as, "interesting" whereas 12% thought the material was either, "dull or boring". Few students (10%) claim to never have looked ahead for answers while the majority of students did look at answers when unable to complete an item. In summary, 94% of students rated programmed instruction as a, "good way to learn about Light".

4.5 OPINIONNAIRE COMMENTS

It is important to consider the students' opinions and attitudes when discussing experimental modes of instruction. The following are a collection of the direct quotations from students expressing additional comments on the experimental methodology. The lists are organized into negative and positive comments. Due to anonymity in collecting the survey data, comments given by limited learners cannot be distinguished from normal learners. The survey results acknowledged many positive
features of programmed instruction and supplied suggestion for future booklet designs. The ratio of positive to negative comments was greater than these lists indicate, approximately five to one.

**Negative Comments**

- It was boring because all you do is look at answers.
- I think it was a fairly good book but I wouldn't want to learn out of it for all subjects.
- They should have the answers on the back of the sheet.
- It should be a little tougher.
- I didn't like the activities because they were too short.
- Should have sections where they tell you to copy notes.

**Positive Comments**

- The booklet was useful because it describes things in detail.
- I would recommend this booklet for other students.
- We should do this on every topic.
- The most interesting part is when the activities came up.
- Just when you're about to quit you get to do something fun.
- I liked it because you don't have to mark it all together.
- It was good because you could work at your own speed.
- I think this exercise should be used more often and I think you would find the results on tests better.
- It was fun knowing what the answer was when you got yours wrong.
- You have lots of time to do it and work at your own speed without being bothered.
- The booklet was worthwhile because it helped me and it was easy to understand.

- It was fun because it was different and exciting.

- The booklet was good because you could experiment and not ask the teacher for the answer.

- It was easy to understand and it helped me get a better mark.

- No homework. I like that!
CHAPTER 5

THE DISCUSSION OF RESULTS

5.0 INTRODUCTION

The following chapter summarizes the purpose and development of the investigation. The conclusions outlined are related to the data analyses displayed in chapter four and concur with literature reports regarding learners in general. A specific knowledge claim is reported for limited learners.

The limitations of the study are explored with various sources of possible error that may affect the overall generalizability of the results. The significance of these results are discussed in terms of the 1978 B.C. Science Assessment and indicate specific areas where programmed materials could find immediate application.

In closing, several unexplored areas of programmed instruction are presented in which future research may yield significant results to further the development of alternate programmed materials for limited learners.
5.1 SYNOPSIS OF STUDY

The purpose of this study was to determine whether or not the use of a programmed instruction booklet, as the basic instructional material, could be considered as more appropriate for limited learners than traditional teaching methods. An attempt was made to measure the success that limited learners have in attaining general science concepts through programmed instruction.

To assess the achievement in general science concepts, an author-developed examination was implemented as a pretest and later as a posttest following the experimental treatment. The mean scores in achievement were calculated for distinct groups thus enabling a comparison of gains in achievement. A non-equivalent control group with a fixed effects factorial design was used in the investigation. The fixed effects analysis of covariance, using the pretest as the covariate, permitted separate analysis of learning ability, methods of instruction and a two-way interaction between these variables.

The outcome of the investigation provided the ensuing discussion of results and conclusions that could be drawn from this study.

5.2 RESULTS

The results of analyses outlined in chapter four provided statistical evidence to answer the research questions and null hypotheses expressed in the first chapter. As initially indi-
cated, the principal research question became one of relativity as to how successful are limited learners, in terms of acquisition of science knowledge with programmed instruction when it is compared with traditional instruction.

Previous studies have indicated that programmed instruction consistently produced at least equal performance of learning objectives when compared with the traditional methods (Ramsey and Howe 1969, Marchese 1977, Royce and Shank 1975). There was insufficient evidence to provide a substantial insight to the success that limited learners were having with programmed instruction in a regular classroom.

The first null hypothesis stating that there was no significant difference of mean performance in science achievement between limited and normal learners was rejected at the 0.05 level of significance. The second null hypothesis regarding no significant difference in mean performance for instruction mode was also rejected. The programmed method of instruction was found to be significantly better than the traditional method of instruction for both limited and normal learners in elevating the mean posttest achievement scores. These findings support the research of Dutton (1963), Leo (1973), Lewis (1974), Peterson (1970) and Williams (1969).
In terms of actual scores out of 30, the limited learners receiving programmed instruction had a mean score gain in achievement of 6.45 from the pretest level of 12.73 to the posttest achievement mean score of 19.18. The normal learners receiving the experimental treatment had a mean score gain in achievement of 6.30 from the pretest level of 15.80 to the posttest level of 22.10. These gains in achievement are statistically significant and were displayed in table 10 along with the mean score gains for traditional teaching.

The third null hypothesis stating that there was no significant interaction between the mode of instruction used (programmed or traditional) and learning ability (limited or normal) was not rejected. There was no significant interaction between these variables at the 0.05 level of statistical significance. Therefore, the null hypothesis was accepted and for the purpose of this study there was no interaction between mode of instruction and learning ability.

In summary, there was a significant difference for normal learners over limited learners in terms of posttest mean achievement scores. All students receiving programmed instruction achieved significantly higher scores than students taught by traditional instruction. Since there was a significant difference for programmed instruction and no interaction between learning ability and instruction mode, it follows that programmed instruction was better for both groups of students. The results of the study are therefore:
1. The limited learners were more successful, in terms of acquisition of science knowledge with programmed instruction than with traditional teaching.

2. The normal learners were more successful, in terms of acquisition of science knowledge with programmed instruction than with traditional teaching.

3. There was no interaction between the mode of instruction used (programmed or traditional) and learning ability (normal or limited).

5.3 LIMITATIONS OF THE STUDY

The study did not attempt to investigate the long term effects of continued instruction through programmed materials on student attitudes or achievement levels. The experimental teaching method was used for three weeks, which represents 7% of the time the students are in school each year. Earlier references to the Hawthorne effect described how the halo effect may limit these findings and caution should be used in applying the results to other situations.

The generalizability of results from the investigation should be used with some discretion. The study was conducted at the grade eight level and the effects of programmed instruc-
tion with learning ability was not explored at other grade levels. Similarly, the positive attitudes expressed by grade eight students may not be applicable to other age levels.

The investigation occurred in one Vancouver high school. The 116 participants in the sample obtained a mean score of 7.3 (out of 15) on the district science survey as compared with a mean score of 8.3 for 2580 students tested in 1980. Whether or not similar results for the programmed booklet would be found in other high schools was not explored.

The teacher factor was one variable assumed to be equivalent in the investigation. One teacher had no previous experience with programmed instruction whereas the author had developed the unit and taught with other programmed materials. Some possible error or experimenter bias may have been introduced at this unexplored level.

The internal validity was limited by the lack of random assignment of the subjects to the treatment. As discussed in section 3.1, the selection of five cluster samples was an attempt made to compensate for the random assignment. Campbell and Stanley (1963), acknowledge the use of naturally formed classes in experiments as an acceptable procedure in the social sciences when the random assignment of subjects to treatment is not possible.
5.4 IMPLICATIONS

The results of the investigation revealed statistical evidence to further support the use of programmed materials for instructional purposes. Significantly greater gains in achievement were discovered for both the limited and normal learners receiving programmed instruction. The difference in mean scores indicated that programmed instruction should be considered as an alternative to the traditional methods of instruction.

Since there was no interaction between the instruction mode and learning ability, it can be suggested that this programmed unit of instruction benefitted all students regardless of their learning ability level. The programmed method has not only been shown to be equivalent to the traditional approach but rather superior to, in terms of gains in posttest achievement scores.

With regards to the B.C. Science Assessment (section 1.41), it is suggested that programmed instruction may meet both the needs of teachers and students. It was recommended by the assessment team as a priority item that the Ministry of Education increase the selection of texts and supplementary reading materials available to teachers of the present junior science curriculum. In the interim, they suggested a wider range of printed materials be designed that are adaptable to ranges in both ability and interest at the junior science level. Programmed materials could satisfy these suggestions and the recommendation that teachers widen their repertoire of teaching methods at the junior secondary level with these materials.
Teachers also reported that there appeared to be insufficient time to cover the prescribed course and that there was little provision in science for individual differences in student ability. The programmed booklet used for this investigation covered the content in less time (section 3.43) and limited learners were more successful than with the traditional approach.

5.5. RECOMMENDATIONS FOR FUTURE RESEARCH

The limitations of the investigation provide insight to other areas of research concerning limited learners and programmed instruction. For example, the study was limited to grade eight students which suggests the question of transfer to other age levels. Research may indicate that programmed instruction is more appropriate for limited learners at all age levels rather than a specific age group.

There was no attempt during this study to measure the success of female versus male limited learners. A further investigation may indicate if programmed materials are more suitable for one sex or the other in enhancing science achievement.

The study was limited to one topic in science (Light). An analysis of programmed instruction into other disciplines of science may indicate if some topics are more conducive to programming than others, for limited learners. Similarly, other goals of science education besides achievement could be explored. There is a need to discover the effect of programmed instruction
on the retention of science knowledge, the processes of science and the skills or techniques developed.

Student attitudes were collected on an opinionnaire in an attempt to gather some general responses towards programmed instruction. A longitudinal study where limited learners are taught exclusively by programmed materials may reveal distinct attitudinal changes when expressed over the long term. Most students responded in a positive manner to the attitudinal survey. An exploration could be undertaken to examine any significant reasons for the favorable responses.

The effects on classroom management offers other areas of research. The teacher's workload, morale and relationship with the limited learners should be determined if programmed instruction is to become a substantial portion of the curriculum. The English as a Second Language (ESL) programs, appear to be deficient in science materials. Programmed materials for limited learners may be of benefit for those students experiencing language difficulties.

The amount of time required to complete programmed units as compared with traditional instruction may yield a more efficient instruction mode. Although time was not a focal point of this investigation, it was found that those students receiving programmed instruction required less time to complete the topic. A quantitative study could expand these findings to establish the most expedient method of instruction.
SELECTED BIBLIOGRAPHY


34. Ferguson, Donald G., "Review of the Literature on the Slow Learner.", Education 81, February 1961.


86. Theofanis, J.C., "A Comparison of Two Methods of Programmed Instruction of a Unit in Magnetism and Electromagnetism with 8th Grade Students," University Microfilms, Ann Arbor, Michigan, 1963.


APPENDIX A

PROGRAMMED INSTRUCTION
ATTITUDINAL EVALUATION

DO NOT WRITE YOUR NAME ANYWHERE ON THIS PAPER

1. Have you ever worked on a programmed instruction before?
   a.) no
   b.) yes
   c.) not sure
   How many times? ________

2. How useful was the booklet in helping you to learn about light?
   a.) very helpful
   b.) helpful
   c.) useless

3. As a classroom activity for one period, how would you rate programmed instruction?
   a.) very good
   b.) average
   c.) boring

4. Would you like to study a unit of science by using ONLY a programmed instruction?
   a.) yes
   b.) no
   Why? ____________________________________________

5. How often would you want to work with a programmed instruction?
   a.) once a week
   b.) once in 2 weeks
   c.) once a month
   d.) once in two months
   e.) never again

6. Describe the booklet you worked with by choosing one word from each group.
a.) difficult  
g.) fun  
b.) average  
h.) average  
c.) easy  
i.) dull  
d.) interesting  
j.) valuable  
e.) average  
k.) average  
f.) boring  
l.) of no value  

7. You are now starting a new topic in science. List the activities (using #1-#8) in order of what you think will be the best way for learning about this topic.

a.) writing out some notes  
b.) watching several films  
c.) study a programmed booklet  
d.) listen to the teacher talk  
e.) read from the textbook  
f.) watch the teacher do an experiment  
g.) begin a library project  
h.) do an experiment yourself

8. You have 30 minutes left in your science class. The teacher will let you do any of the activities listed below. For each, list them in order of what you would select if given a choice. (Write 1 beside your favorite, 4 next to the least desirable.)

a.) write out notes  
   watch a film  
   work on practice problems  
   a programmed booklet  

b.) watch the teacher do a demonstration  
   listen to the teacher talk  
   do an experiment yourself  
   work on a programmed instruction  

c.) begin a library project  
   write a test  
   read from the textbook  
   start a programmed booklet

9. If our library had a set of programmed booklets on all subjects for what one main use could they be to you.

a.) reviewing for a test  
b.) advanced learning into other topics  
c.) a general study method for daily assignments  
d.) locate information on topics that you did not clearly understand
10. How many times did you look ahead for answers?
   a.) never
   b.) one to four times
   c.) five to ten times
   d.) over ten times

11. Was working on the booklet more tiring than a normal class?
   a.) yes
   b.) no
   Why? ____________________________________________________________

12. Was this a good way to learn about light?
   a.) yes
   b.) no

COMMENTS: ________________________________________________________
__________________________
__________________________
__________________________
APPENDIX B

PROGRAMMED INSTRUCTION
LIGHT POSTTEST
M. DOW

INSTRUCTIONS: Select the best answer for each question by writing the CAPITAL LETTER ON YOUR ANSWER SHEET.

1.) An example of a NON-LUMINOUS object is
A.) the sun  
B.) the moon  
C.) a lit candle  
D.) a star  
E.) a fluorescent tube

2.) The speed of light is _______ kilometres per second.
A.) 300,000  
B.) 3,000,000  
C.) 30,000  
D.) 187,000  
E.) 1,870,000

3.) Materials that stop light from passing through them are:
A.) transparent  
B.) translucent  
C.) opaque  
D.) solids  
E.) transmitters

4.) You cannot see light in a curved rubber tube because
A.) darkness absorbs light  
B.) light goes in straight lines  
C.) light must enter your eyes  
D.) detection is too slow  
E.) both B and C

5.) Materials which allow all the light to pass through are
A.) transparent  
B.) translucent  
C.) opaque  
D.) solids  
E.) liquids

6.) Which of the following words means, "to glow with heat."
A.) incandescent  
B.) fluorescent  
C.) bioluminescent  
D.) chemiluminescent  
E.) irridescent

7.) If a source of energy RADIATES, it will
A.) kill life  
B.) absorb light  
C.) shine only in one direction  
D.) cause cancer  
E.) spread out in all directions
8. The image created from the above arrangement is best described as

A) real and upright.
B) real and inverted.
C) virtual and upright.
D) virtual and inverted.
E) none of the above.

9. Pinhole images form because light

A) reflects.
B) refracts.
C) travels in straight lines.
D) is absorbed.
E) is invisible.

10. What do you call an image that is upside down from an object?

A.) virtual
B.) unreal
C.) inverted
D.) reversed
E.) illuminated

11. A Solar Eclipse happens every time the

A.) Moon is between the Sun and the Earth
B.) Earth stops light from reaching the Moon
C.) Moon stops light from reaching the Earth
D.) Sun sends light to the Moon
E.) Both A and B

12. Consider the following objects:
   i) a campfire
   ii) a bolt of lightning
   iii) a desk
   iv) a plant

Are any of the above luminous light sources?

A.) all of them
B.) none of them
C.) iii) only
D.) i) and ii) only
E.) i), ii), and iv) only
13.) Light can do work and make plants
A.) invisible                     D.) weak
B.) move                          E.) die
C.) dry out

14.) The wire inside a light bulb is called
A.) copper                       D.) aluminum
B.) a fuse                        E.) lead
C.) a filament

15.) Light made by people is called _________ light.
A.) natural                      D.) artificial
B.) fluorescent                  E.) bioluminescent
C.) synthesized

16.) Objects which produce light are
A.) transparent                  D.) nonluminous
B.) luminous                     E.) real
C.) opaque

17.)

As the object distance $D_o$ increases in the above diagram, the shadow on the screen

A) becomes larger.
B) becomes smaller.
C) stays the same size.
D) disappears.
E) is none of the above.
18.) By changing the position of a light source, a shadow may have a different
A.) size D.) location
B.) shape E.) all the above
C.) darkness

19.) In a bathroom mirror, your reflection appears to be
A.) shorter D.) thinner
B.) the same height E.) wider
C.) taller

20.) Of the following, which is the correct image of the word Physics as you would see it reflected in a plane mirror?
A) Physics
B) Physics
C) Physics
D) Physics
E) None of the above

21.) Light is a form of ____________.
A.) heat D.) lightning
B.) electricity E.) energy
C.) sound

22.) Without any source of light, all living things would
A.) become deaf D.) move underground
B.) become dead E.) produce oxygen
C.) become cold

23.) An image is ____________ a real object.
A.) the same size as D.) the opposite of
B.) a similar likeness of E.) a negative reflection of
C.) smaller than

24.) A window that does not permit a clear view of objects on the other side is
A.) luminous D.) translucent
B.) nonluminous E.) opaque
C.) transparent
25.) Which of the following is a real image?

A.) a movie picture  
B.) a tree  
C.) a person  
D.) a lighted bulb  
E.) a desk

26.) A shadow is

A.) an area where light is blocked out  
B.) an absence of light  
C.) where light shines  
D.) cast only by transparent objects  
E.) both B and D

27.) During a solar eclipse, the Earth, Sun and Moon all line up. Which of these three is in the middle?

A.) the Sun  
B.) the Moon  
C.) the Earth  
D.) the Earth or the Moon  
E.) the Sun or the Moon

28.) Most light in the Universe comes from

A.) the moon and planets  
B.) chemicals in the earth  
C.) the sun and stars  
D.) fires  
E.) light bulbs or candles

29.) A LUMINOUS object is one that

A.) reflects light  
B.) does not reflect light  
C.) absorbs light  
D.) gives off light  
E.) both B and C

30.) Light travels

A.) through all solids  
B.) through all liquids  
C.) in circular motions  
D.) in spiral patterns  
E.) in straight lines
APPENDIX C:

ITEM ANALYSIS OF ACHIEVEMENT POSTTEST

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<th>Test Item</th>
<th>Difficulty Index</th>
<th>Discrimination Index</th>
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Hoyt Estimate of Reliability = 0.66

Standard Error of Measurement = 2.08
APPENDIX D

A PERSONALIZED INSTRUCTION

COURSE: Science 8

TARGET POPULATION: ages 12 through 15 years

SECTION: Physics

TOPIC: Light

PROBABLE CLASS SIZE: 30 students

SPECIFIC CONTENT AREAS COVERED:

1. describing light sources
2. transmission of light
3. shadows
4. introducing ray diagrams
5. formation of images

PRE-INSTRUCTIONAL REQUIREMENTS:

- a reading level of approximately grade 5 (C.T.B.S.)
- an ability to follow written instructions for specific activities
BEHAVIORAL OBJECTIVES

The following is a list of terminal behaviors that students will possess at the completion of each section. The student will be able to:

PART A: Light Sources

- describe light as a form of energy,
- relate the importance of light to living things,
- list different light sources and ways of producing light,
- define the meanings of the words; incandescent, luminous, non-luminous, filament, artificial, emit, and illuminate,
- describe light sources by using the terms, point or broad, luminous or non-luminous, and natural or artificial,

PART B: Transmission of Light

- explain that light travels in straight lines in all directions,
- define what is meant by the words; radiate, reflect, absorb, ray, opaque, translucent, transparent, invisible, and transmit,
- recognize the speed of light as 300 000 km/s,
- calculate simple problems using the speed of light,
- describe the behavior of light when striking opaque, translucent and transparent objects,
- classify materials by their ability to transmit light,
PART C: Shadows

- explain the formation of shadows,
- describe that shadows can be made larger or smaller by moving the opaque object,
- define the terms; shadow, umbra, penumbra, predict, and solar eclipse,
- draw a ray diagram of a light source, an opaque object and a screen,
- identify and label different types of shadows on ray diagrams and in the real world,
- relate the circumstances required for a solar eclipse to occur,

PART D: Formation of Images

- describe that an image looks like something real because of the way it reflects light,
- identify real images as those that can be projected on a screen,
- define the terms; image, upright, inverted, real image and virtual image,
- use a ray diagram to explain the formation of images,
- describe why a pinhole image on a screen appears upside down,
- specify that virtual images as seen in a mirror are upright but laterally reversed,
- demonstrate how to make pinhole images larger or smaller on a screen.